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Uzen Oilfield: A Case Study of Soviet Mismanagement

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A Research Paper

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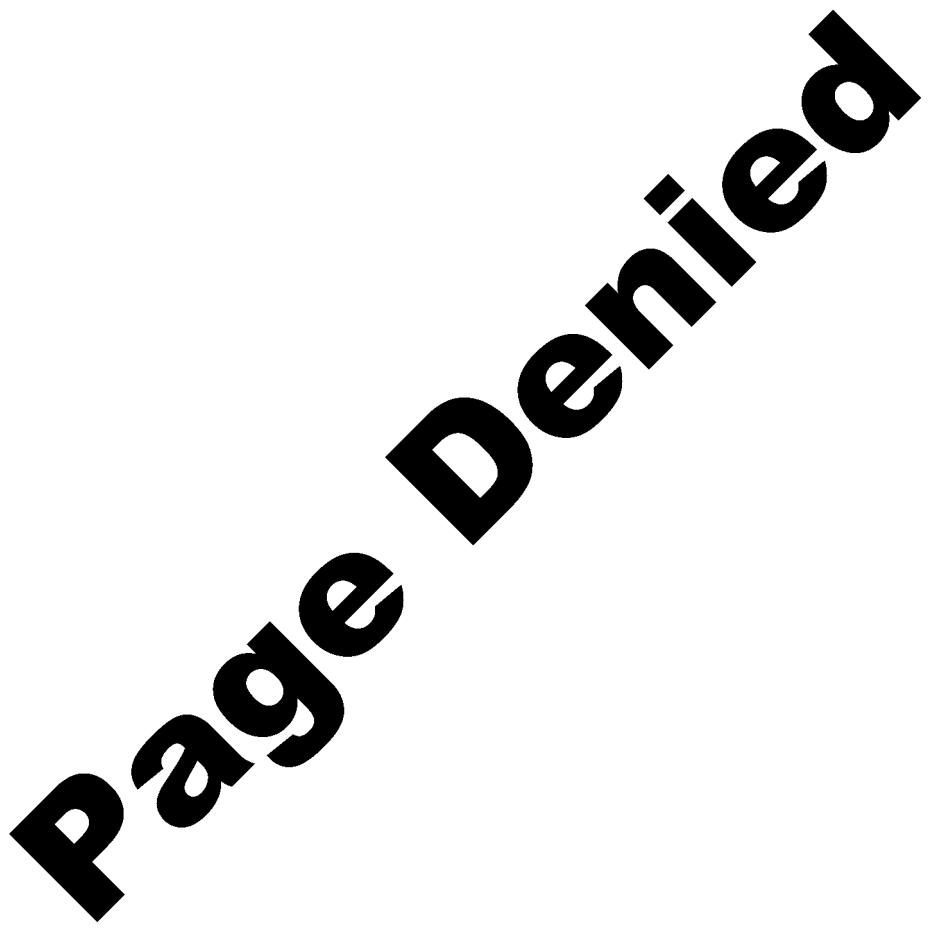

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A Research Paper

This paper was prepared by
of the Office of Global
Issues, with a contribution from
Comments and queries are welcome and may be addressed to the Chief, Resource Analysis Branch, OGI,

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This paper was coordinated with the National Intelligence Council.

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Summary

Information available as of 1 November 1982 was used in this report.

Discovery of the Uzen oilfield on the Mangyshlak Peninsula in 1961 gave Soviet energy planners high expectations for the potential contribution that it and the other fields in surrounding Kazakhstan would make to national oil production. Development of the petroleum resources of West Siberia had not yet begun, and the Soviets were searching for advantageously located deposits in the western USSR rich enough to replace the Volga-Urals fields when they began to decline. Soviet geologists had assessed the hydrocarbon content of the Caspian Sea basin as high and were looking to the future of Uzen with optimism.

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Some 20 years later, however, Soviet literature suggest that Uzen oilfield has not met Soviet expectations. Although the field contained enough potential reserves at discovery to place it in the medium-giant category—an oilfield must contain 500 million barrels of recoverable reserves to be considered a giant—Soviet engineers have been unable to overcome recovery problems caused by the complexity of the reservoirs and the poor characteristics of the crude oil. As a result, the reservoirs have been permanently damaged and annual field output has lagged far behind production goals. Our analysis of possible future production scenarios shows that the observed decline of Uzen—the field peaked in 1975—will continue at least through the year 2000. We see no prospects for anything more than a slowing of this trend regardless of any new strategies the Soviets may employ.

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In large measure, Uzen provides an excellent case study of how poor field management and the traditional Soviet emphasis on initial high output rates can lower long-term oil production. The Soviets are currently attempting to rehabilitate Uzen with a variety of expensive Western recovery processes and equipment, much of which is inappropriate, according to our engineering analysis. This suggests that developers at other fields in Kazakhstan and perhaps the rest of the country may perpetuate mistakes made at Uzen. In view of the likelihood of continued inappropriate development practices and difficulties in obtaining Western equipment, we doubt that Kazakhstan will offer the USSR a significant source of additional oil production over this decade.

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Background

The Kazakh SSR currently provides the USSR with about 3 percent of its oil supply. Although this contribution is relatively small, open sources indicate that the Soviets regard both the onshore and offshore potential of the entire Kazakhstan–Caspian Sea area as significant (figure 1). Kazakhstan and the Timan-Pechora region of the Komi ASSR are the two areas outside of West Siberia that have shown the greatest growth in petroleum production during recent years, and many Soviet oil experts rate their potential for future increases as high.

Thus far, however, the Soviets have been frustrated in their efforts to make the key oilfields in Kazakhstan meet expectations. The high viscosity and paraffin content of the oil have presented a special, and rather unfamiliar, challenge to Soviet engineers, one that has led them to experiment—often unsuccessfully—with a variety of oil recovery techniques.

- Growth in oil output outside of West Siberia has largely come to a halt at a time when national oil output is in the doldrums. Soviet oil prospects during this decade could improve significantly if the Soviets could turn their luck around in a region where large amounts of oil remain and the production infrastructure is already in place. According to Soviet literature, some Soviet geologists think that Kazakhstan might be such a region.

- The Soviet oil industry has been consistently troubled by its poor execution and faulty field development practices. Nowhere has this been more apparent than at Uzen oilfield in Kazakhstan, which provides a useful case study of the limited ability of the Soviet oil industry to develop difficult oil deposits.

Our Analytical Approach

The Soviets have not published detailed field production data for some time, particularly for major oilfields. The little information they have made available has usually been conflicting or simply not credible. 25X1

To make matters worse, the Soviets treat data concerning their oil reserves as a state secret; consequently, we do not know what they currently believe their reserves to be—much less what those reserves might actually be. 25X1

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Uzen Oilfield

Uzen is the largest of a series of major oilfields located near the coast of the Caspian Sea in Kazakhstan's Mangyshlak Oblast (figure 2). The Soviets discovered the Uzen field in 1961 after an extensive exploration program begun before World War II in the Caspian Sea basin. In the early 1960s the Soviets faced an energy supply situation somewhat similar to the one confronting them today. Most of the oil production was coming from a single region, the Volga-Urals, which was reaching its capacity. With

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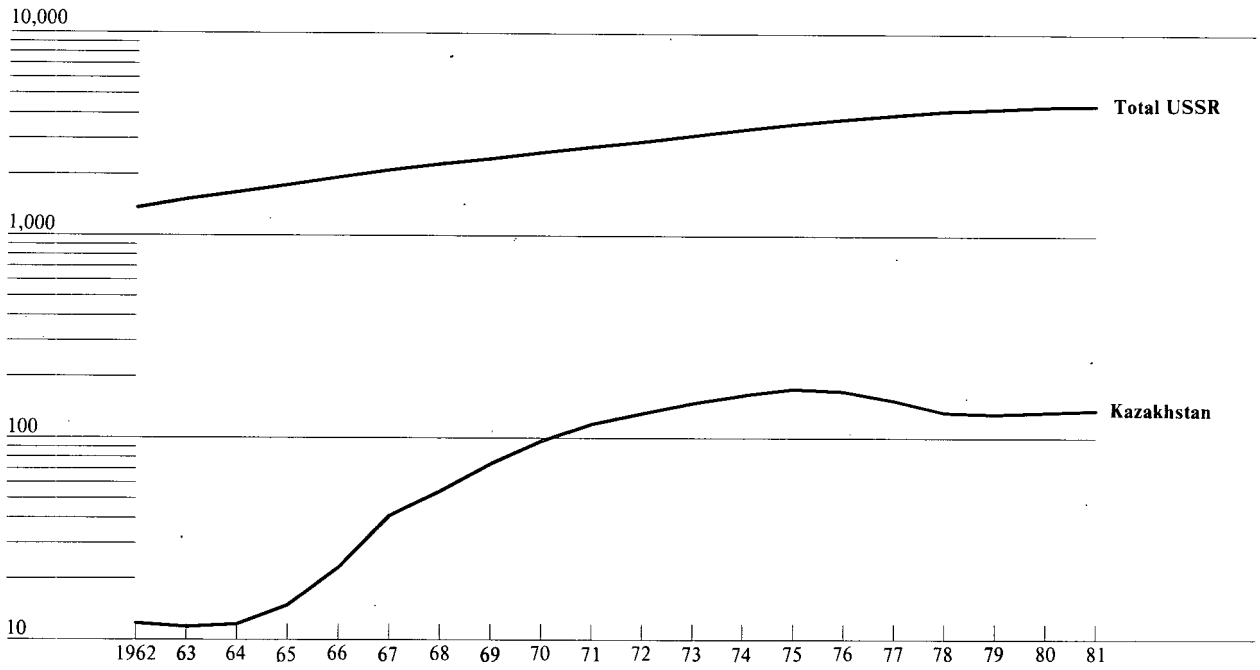
Figure 1
USSR: Oil Production History—Total vs Kazakhstan
Million barrels



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growth in national production slowing, Soviet geologists were looking for a series of new, oil-rich deposits—preferably located in the western USSR close to existing production infrastructure and refineries—that could boost growth and eventually replace the output from the Volga-Urals region. At that time, the Soviets had not fully evaluated the potential of West Siberia nor begun production operations there. Soviet literature indicates that Uzen, which appeared to be a possible supergiant, was initially viewed as a field with great promise that would play a significant role in Soviet energy resource planning during the 1960s and 1970s.

Oil in Place and Reserves

Our volumetric calculations indicate that the reservoirs at Uzen originally contained some 7 billion barrels of oil. Nevertheless, the field has been difficult to develop.

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production comes from at least 25 individual sandstone reservoirs and that the rock and fluid properties vary widely not only from one reservoir to another but also within each reservoir. Producing oil from such heterogeneous, complex reservoirs presents an engineering challenge that the Soviets have found difficult to meet (figure 3).

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The high paraffin content of Uzen oil has also caused problems for the Soviets. Paraffin remains in solution at natural reservoir temperature and pressure but will

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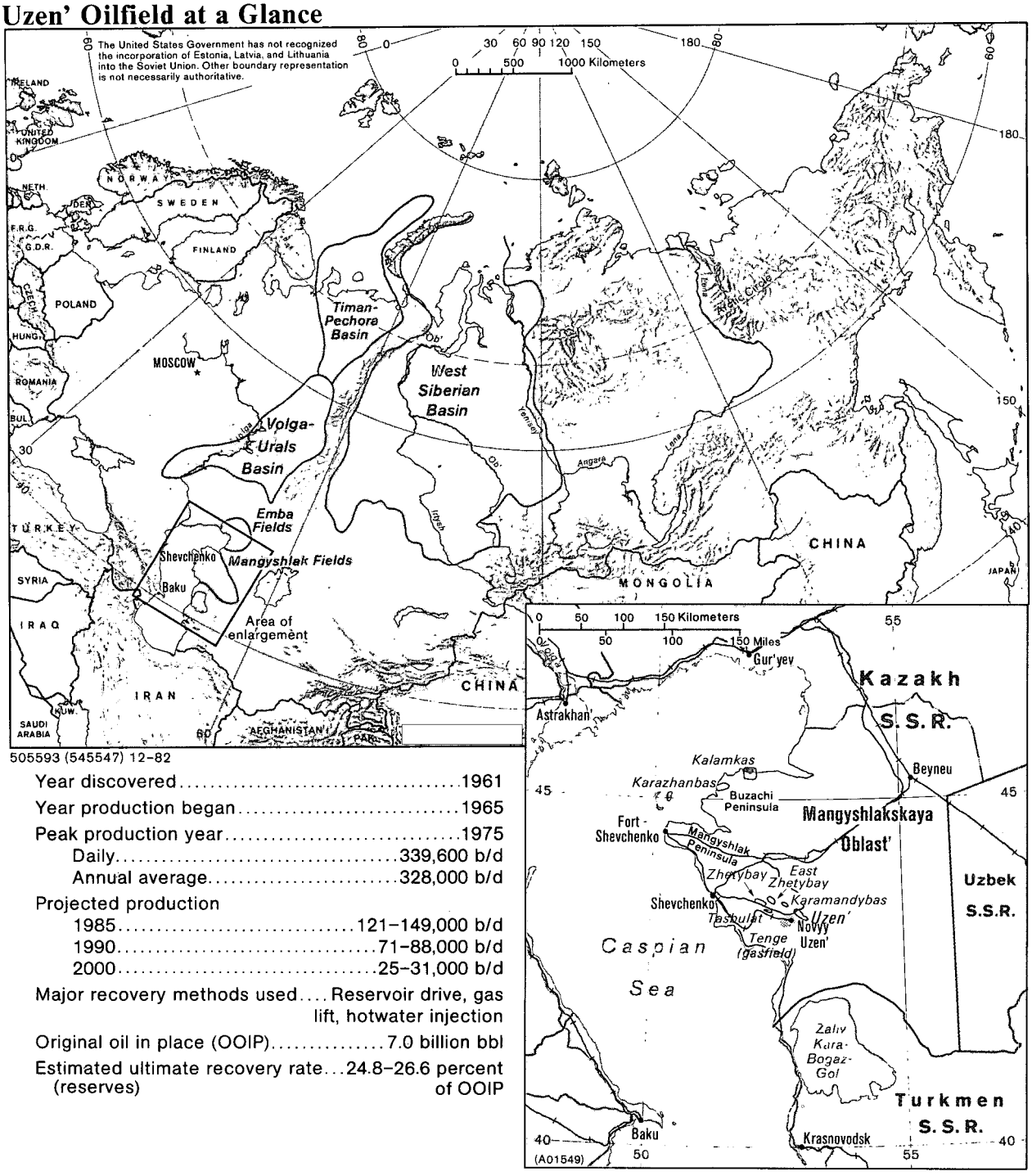
Figure 2
Uzen' Oilfield at a Glance



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Year discovered	1961
Year production began	1965
Peak production year	1975
Daily	339,600 b/d
Annual average	328,000 b/d
Projected production	
1985	121–149,000 b/d
1990	71–88,000 b/d
2000	25–31,000 b/d
Major recovery methods used	Reservoir drive, gas lift, hotwater injection
Original oil in place (OOIP)	7.0 billion bbl
Estimated ultimate recovery rate (reserves)	24.8–26.6 percent of OOIP

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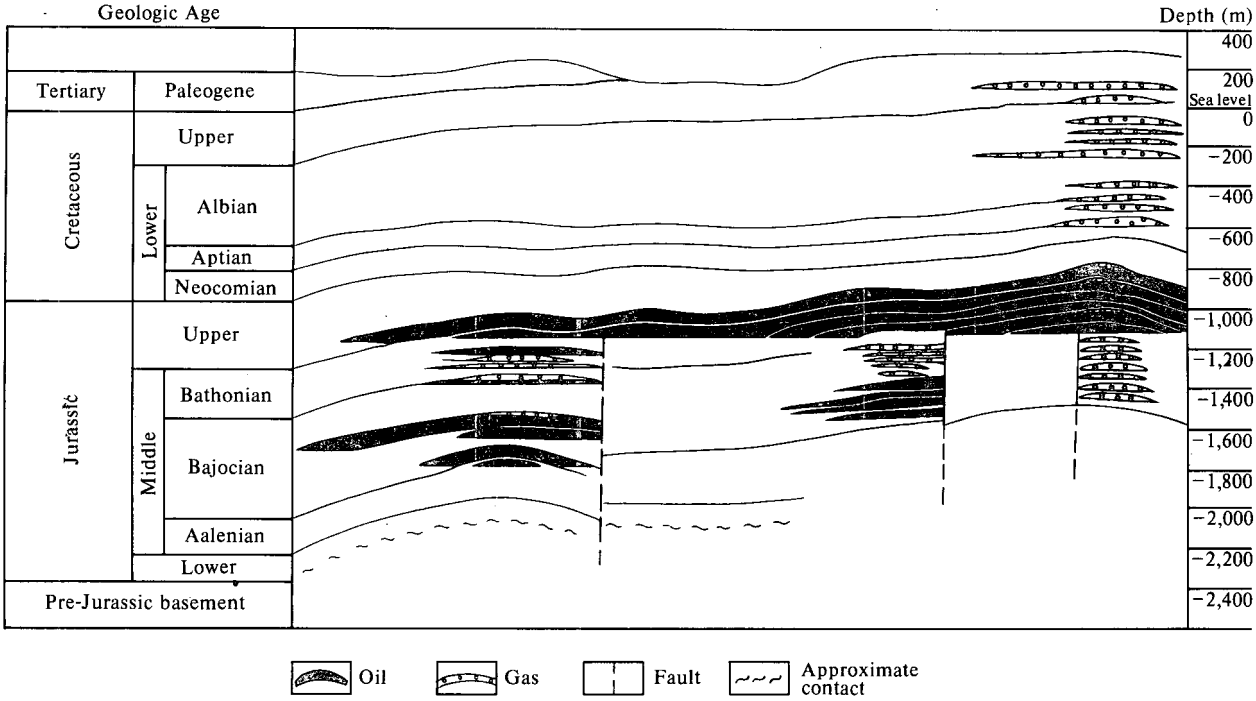
Figure 3
Uzen Oilfield: Generalized Cross Section



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crystallize and collect in reservoir rock void space and on pipe surfaces when the temperature of the oil drops. At Uzen a drop in crude oil temperature of only 5° C to 10° C causes paraffin formation. Such narrow temperature tolerance complicates both the operation of the field and the surface treatment and transportation of the oil.

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The original development plan for Uzen—as published by the Soviets—called for parallel rows of hot water injection wells perpendicular to the long axis of the field, dividing the field into blocks of production wells.

Soviet literature suggests—

—that Uzen's troubled production history owes its origins to reservoir damage that occurred in 1967 when the Soviets, in their rush to boost production, initiated a field-wide injection program using cold, untreated Caspian Sea water. The cooling effect of the injected seawater caused the paraffin to solidify and clog the reservoir pore spaces, especially in the areas surrounding the injection wells. The paraffin plugging reduced the ability of the injected water to sweep the oil toward production wells. The injected water also tended to take the course of least resistance through the more permeable zones of the reservoir rock, thus bypassing oil in some areas and causing rapid rises in the water cut, the proportion of water produced with the oil.

Soviet field managers were well aware that rapid development of the field could cause grave difficulties for future recovery, but they proceeded anyway. According to one open source, as early as 1967 scientists at the Moscow All-Union Petroleum Scientific Research Institute recognized the seriousness of the paraffin problem and recommended heating all injection water. However, the Kazakh Institute for Design and Planning of Establishments of the Petroleum Industry, primarily concerned with meeting short-term production goals, ignored the recommendations. We have seen this pattern repeated frequently in the Soviet oil industry, most recently at several major oilfields in West Siberia. Had the West Siberian fields not been less complex and their oil of lower paraffin content, production would have been more significantly diminished there also. 25X1

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By 1969 the large-scale injection of cold saltwater had caused other negative side effects. Salts dissolved in the untreated injection water interacted with the reservoir fluids to produce corrosive and noncorrosive deposits on the insides of well tubing, surface equipment, and pipelines. This further decreased lifting capabilities and complicated maintenance of surface facilities. The corrosion problem was compounded by the presence of highly toxic hydrogen sulfide in the crude oil gas. According to Soviet literature, the improper treatment of this gas resulted in extensive damage to field production equipment and pipelines. 25X6

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Correcting the Damage

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Thus, most of the activity at the field during the past 10 years has been to remedy previous errors in order to recover as much oil as possible. Desulfurizing facilities were completed at the main gas processing plant in 1980 to limit corrosion buildup in the pipelines and equipment, and injection water is now desalinized at Shevchenko before it is piped to Uzen and injected. The Soviets have also been attempting a variety of specialized recovery techniques for the field. 25X1

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Hot Water Injection. The Soviets are now concentrating their efforts on hot water injection, both to limit corrosion and paraffin damage and to improve the ability of the injection water to sweep the oil to the production wells. 25X1

to date, this experimentation has been successful neither in checking the paraffin accumulation nor in reversing the buildup. Slow implementation is part of

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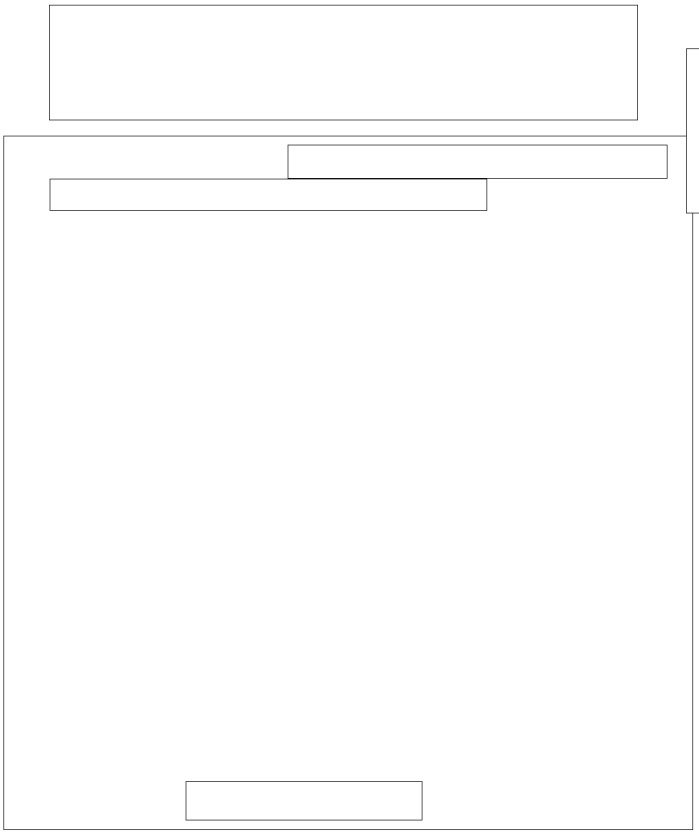

Gas Lift. Gas lift has given better results than any other recovery technique tried at Uzen. The Soviets used an indigenously designed system for most of the oil produced in 1981 at the field. A gas-lift system injects compressed gas into the well bore, lightening the fluid column and increasing the rate of fluid production. Though it will not significantly increase total oil recovery, it can sharply increase daily production rates.

Experimentation with the gas-lift system began at Uzen in 1969 and recovery efficiency increased immediately. The system was rapidly expanded, and by 1975, gas-lift wells were producing approximately 60 percent of Uzen's oil (averaging more than 500 b/d per well with 25 percent water cut). At that time the Soviets claimed to be converting approximately 170 wells to gas lift each year.

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The operation of the gas-lift network at Uzen has been continually plagued by paraffin deposition in the well bores and corrosion in the gas lines and equipment. In 1974 a change in gas source from the Tenge field to the Kazakh Gas Refinery caused further complications in the gas-lift process. The refined gas contained a much higher concentration of impurities and water than the system could tolerate, and the lower gas temperature also caused noncorrosive deposits to restrict flow in the gas lines. We know from Soviet literature that, of the various measures taken to improve the conditions, the use of chemicals as corrosion inhibitors has proved most effective.

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Production Forecast

To estimate the future contribution of Uzen to Soviet national oil supplies, we evaluated both a base case and a best case scenario (figure 4). The base case assumes a continuation of the current field development strategy with no major changes in operating practices. That is, conventional pump-lifting methods would predominate, the network of gas-lift wells would not exceed approximately 30 percent of the total number of wells in use, and limited experimentation with hot water injection would continue. Under this scenario, a decline curve analysis reveals that Uzen's production will continue to drop by some 10 percent annually, to approximately 120,000 b/d by 1985 and to 25,000 b/d by the year 2000. Expected ultimate oil recovery would be about 25 percent of original oil in place.

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The best case, which postulates an expanded gas-lift program, represents the maximum the Soviets can reasonably expect to accomplish at Uzen. This scenario assumes the refurbishment of the existing gas-lift well network and the conversion of some 50 conventional wells annually to gas lift through 1984, with no

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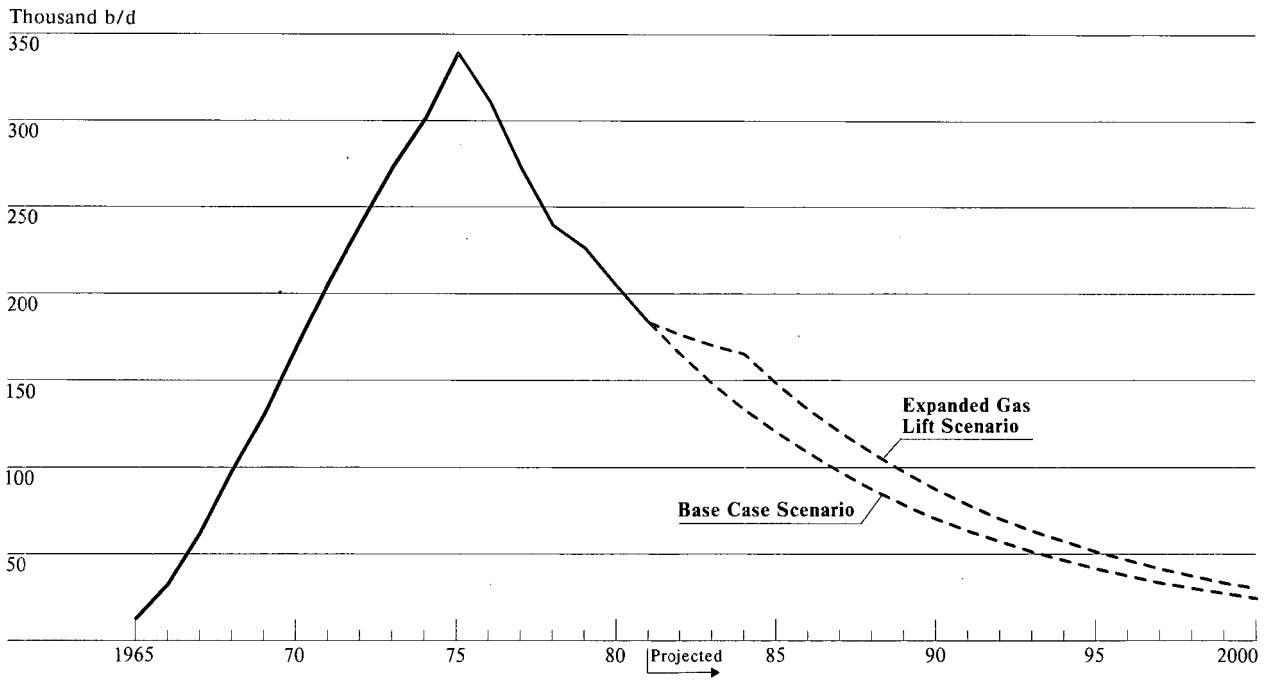
Figure 4
Uzen Oilfield: Oil Production History and Forecast



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change in the total count of working wells. This scenario, which appears to be what the Soviets are now trying to do, does not include additional thermal operations because we believe they would not be effective. Our decline curve analysis in this scenario indicates that production at Uzen would drop to about 150,000 b/d in 1985, decrease to some 90,000 b/d by 1990 and to 30,000 b/d by the year 2000. Expected ultimate oil recovery would be approximately 27 percent of original oil in place.

during 1981 the Soviets planned to install new compressor facilities and add more gas-lift wells to the present system. Uzen's producing wells are already at optimum density, however, making it unlikely that a large number of new wells would be drilled to expand the gas-lift system, but rather that the existing wells would be converted.

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As indicated in the oil production forecast, we believe that an expansion of the gas-lift system at Uzen would result in a temporary production increase. Production would be slightly higher than the base case but still decline at approximately the same rate; and ultimate oil recovery would be only 2 percentage points higher. Thus, in light of the ineffectiveness of steam and the polymer supply problem, there is little the Soviets can do to alter the fate of Uzen.

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Lessons Learned—And Not Learned

The Soviets have learned a painful but useful lesson from their development errors at Uzen oilfield. The current costly and largely unsuccessful attempt to maintain production at this once-promising giant has driven home the importance of instituting an effective field development program in the early stages. That the Soviets have learned at least this much is evident in their attempt to implement systematic thermal recovery programs at Kalamkas and Karazhanbas, the neighboring fields on Mangyshlak Oblast's Buzachi Peninsula. 25X1

At the same time, however, the institutional and technical shortcomings of the Soviet oil industry appear to be limiting the full application of this experience. The Soviets, for example, are currently attempting to purchase a variety of expensive Western recovery processes for Uzen, much of which is inappropriate for use at the field. And despite somewhat better initial planning, even Kalamkas and Karazhanbas were put on line in a hasty manner in order to start production as soon as possible and at any cost. 25X1

Outside of Kazakhstan, the lessons of Uzen appear to have had even less impact. Our continuing analysis of key Soviet oilfields reveals that, most notably in oil-rich West Siberia, Soviet field managers continue to apply hasty and sometimes ill-conceived field development practices—often against the advice of their own scientific experts. The end result of this is that the Soviets are trading larger, stable oil recovery in favor of high but shorter lived production rates. With growth in Soviet oil production at a near standstill, however, the true cost of this trade-off may now be becoming even more apparent. 25X1